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1. Introduction

The National Climatic Data Center (NCDC) is the "Nation's Scorekeeper" in terms of addressing severe weather events in their historical perspective. NCDC has developed an "Extreme Weather and Climate Events" WWW system to showcase its efforts in making that type of information available to its users. The web page (Fig 1) is at the following address: <http://www.ncdc.noaa.gov/extremes.html>. This system handles well over two million users per year.

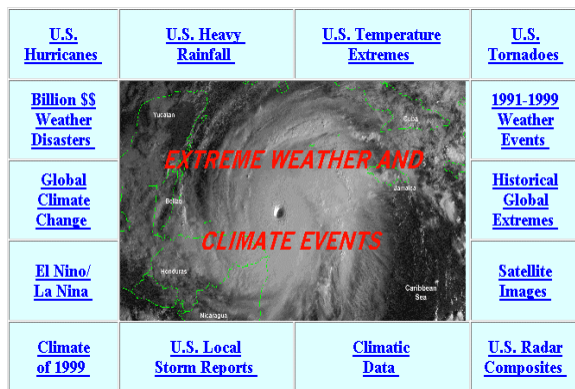


Fig 1. Extreme Weather and Climate Events

As part of its responsibility of "monitoring and assessing the climate," NCDC tracks and evaluates climate events in both the U.S. and globally that have great economic and societal impacts. NCDC has frequently been called upon to provide summaries of global and US temperature and precipitation trends, extremes, and comparisons in their historical perspective.

2. U.S. Events

The U.S. sustained forty-four weather-related disasters during the 1980-1999 period in which overall damages/costs reached or exceeded \$1 billion. Thirty-eight of these disasters occurred during the 1988-1999 period with total damages/costs exceeding \$170 billion. Seven occurred during 1998 alone—the most for any year on record.

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Following is a list of these disasters in a time-descending order. Two damage figures are given for events prior to 1996—the first figure represents actual dollar costs at the time of the event and is not adjusted for inflation. Therefore, event costs over time should not be compared using this value. The second value in parenthesis (if given) is the dollar cost normalized to 1998 dollars using a GNP inflation/wealth index. Figures 2 and 3 (below) provide graphical representations of these statistics.



Fig 2. Billion Dollar U.S. Weather Disaster Map, 1980-1999, Adjusted Costs

These statistics were taken from a wide variety of sources and represent, to the best of our ability, the estimated total costs of these events---that is, the costs in terms of dollars and lives that would not have been incurred had the event not taken place. Insured and uninsured losses are included in damage estimates. Economic costs are included for wide-scale, long-lasting events such as drought. Estimates are periodically updated as more data/information become available. Sources include the National Weather Service, the Federal Emergency Management Agency, other U.S. government agencies, individual state emergency management agencies, and insurance industry estimates. The WWW version of this report (<http://www.ncdc.noaa.gov/ol/reports/billionz.html>, accessible via Fig 1) includes links to detailed technical reports on many of these events.

1. **Hurricane Floyd** September 1999. Large, category 2 hurricane makes landfall in eastern NC, causing 10-20 inch rains in 2 days, with severe flooding in NC and some flooding in SC, VA, MD, PA, NY, NJ, DE, RI, CT, MA, NH, and VT; preliminary estimates of at least \$6.0 billion damage/costs; 77 deaths.

2. **Eastern Drought/Heat Wave** Summer 1999. Very dry summer and high temperatures, mainly in eastern U.S., with extensive agricultural losses; over \$1.0 billion damage/costs; estimated 256 deaths.

3. **Oklahoma-Kansas Tornadoes** May 1999. Outbreak of F4-F5 tornadoes hit the states of Oklahoma and Kansas, along with Texas and Tennessee, Oklahoma City area hardest hit; at least \$1.0 billion damage/costs; 55 deaths.

panhandle, 15-30 inch 2-day rain totals in parts of AL/FL; estimated \$5.9 billion damage/costs; 16 deaths.

7. **Hurricane Bonnie** August 1998. Category 3 hurricane strikes eastern North Carolina and Virginia, extensive agricultural damage due to winds and flooding, with 10-inch rains in 2 days in some locations; approximately \$1.0 billion damage/costs; 3 deaths.

8. **Southern Drought/Heat Wave** Summer 1998. Severe drought and heat wave from Texas/Oklahoma eastward to the Carolinas; \$6.0-\$9.0 billion damage/costs to agriculture and ranching; at least 200 deaths.

9. **Minnesota Severe Storms/Hail** May 1998. Very damaging severe thunderstorms with large hail over wide areas of Minnesota; over \$1.5 billion damage/costs; 1 death.

10. **Southeast Severe Weather** Winter-Spring 1998. Tornadoes and flooding related to El Nino in southeastern states; over \$1.0 billion damage/costs; at least 132 deaths.

11. **Northeast Ice Storm** January 1998. Intense ice storm hits Maine, New Hampshire, Vermont, and New York, with extensive forestry losses; over \$1.4 billion damage/costs; 16 deaths.

12. **Northern Plains Flooding** April-May 1997. Severe flooding in Dakotas and Minnesota due to heavy spring snow melt; approximately \$3.7 billion damage/costs; 11 deaths.

13. **MS and OH Valleys Flooding & Tornadoes** March 1997. Tornadoes and severe flooding hit the states of AR, MO, MS, TN, IL, IN, KY, OH, and WV, with over 10 inches of rain in 24 hours in Louisville; estimated \$1.0 billion damage/costs; 67 deaths.

14. **West Coast Flooding** December 1996-January 1997. Torrential rains (10-40 inches in 2 weeks) and snow melt produce severe flooding over portions of CA, WA, OR, ID, NV, and MT; approximately \$3.0 billion damage/costs; 36 deaths.

15. **Hurricane Fran** September 1996. Category 3 hurricane strikes North Carolina and Virginia, over 10-inch 24-hour rains in some locations, extensive agricultural and other losses; over \$5.0 billion damage/costs; 37 deaths.

16. **Southern Plains Severe Drought** Fall 1995 through Summer 1996. Severe drought in agricultural regions of southern plains--Texas and Oklahoma most severely affected; approximately \$5.0 billion damage/costs; no deaths.

17. **Pacific Northwest Severe Flooding** February 1996. Very heavy, persistent rains (10-30 inches) and melting snow over OR, WA, ID, and western MT; approximately \$1.0 billion damage/costs; 9 deaths.

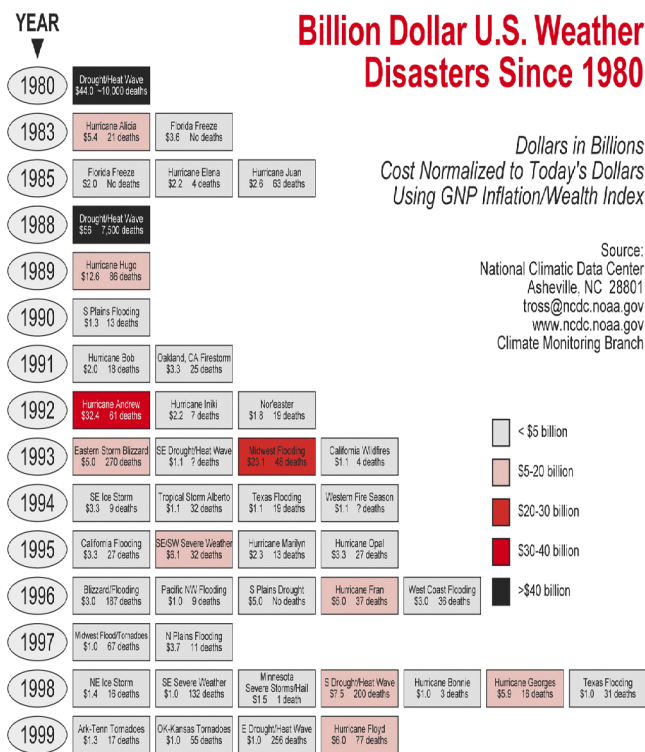


Fig 3. Billion Dollar U.S. Weather Disasters, 1980-1999 - Chronological Chart

4. **Arkansas-Tennessee Tornadoes** January 1999. Two outbreaks of tornadoes in 6-day period strike Arkansas and Tennessee; approximately \$1.3 billion damage/costs; 17 deaths.

5. **Texas Flooding** October-November 1998. Severe flooding in southeast Texas from 2 heavy rain events, with 10-20 inch rainfall totals; approximately \$1.0 billion damage/costs; 31 deaths.

6. **Hurricane Georges** September 1998. Category 2 hurricane strikes Puerto Rico, Florida Keys, and Gulf coasts of Louisiana, Mississippi, Alabama, and Florida

18. **Blizzard of '96 Followed by Flooding** January 1996. Very heavy snowstorm (1-4 feet) over Appalachians, Mid-Atlantic, and Northeast; followed by severe flooding in parts of same area due to rain & snow melt; approximately \$3.0 billion damage/costs; 187 deaths.
19. **Hurricane Opal** October 1995. Category 3 hurricane strikes Florida panhandle, Alabama, western Georgia, eastern Tennessee, and the western Carolinas, causing storm surge, wind, and flooding damage; over \$3.0 (3.3) billion damage/costs; 27 deaths.
20. **Hurricane Marilyn** September 1995. Category 2 hurricane devastates U.S. Virgin Islands; estimated \$2.1 (2.3) billion damage/costs; 13 deaths
21. **Texas/Oklahoma/Louisiana/Mississippi Severe Weather and Flooding** May 1995. Torrential rains, hail, and tornadoes across Texas - Oklahoma and southeast Louisiana - southern Mississippi, with Dallas and New Orleans area (10-25 inch rains in 5 days) hardest hit; \$5.0-\$6.0 (5.5-6.6) billion damage/costs; 32 deaths.
22. **California Flooding** January-March 1995. Frequent winter storms cause 20-70 inch rainfall and periodic flooding across much of California; over \$3.0 (3.3) billion damage/costs; 27 deaths.
23. **Western Fire Season** Summer-Fall 1994. Severe fire season in western states due to dry weather; approximately \$1.0 (1.1) billion damage/costs; death toll undetermined.
24. **Texas Flooding** October 1994. Torrential rain (10-25 inches in 5 days) and thunderstorms cause flooding across much of southeast Texas; approximately \$1.0 (1.1) billion damage/costs; 19 deaths.
25. **Tropical Storm Alberto** July 1994. Remnants of slow-moving Alberto bring torrential 10-25 inch rains in 3 days, widespread flooding and agricultural damage in parts of GA, AL, and panhandle of Florida; approximately \$1.0 (1.1) billion damage/costs; 32 deaths.
26. **Southeast Ice Storm** February 1994. Intense ice storm with extensive damage in portions of TX, OK, AR, LA, MS, AL, TN, GA, SC, NC, and VA; approximately \$3.0 (3.3) billion damage/costs; 9 deaths.
27. **California Wildfires** Fall 1993. Dry weather, high winds and wildfires in Southern California; approximately \$1.0 (1.1) billion damage/costs; 4 deaths.
28. **Midwest Flooding** Summer 1993. Severe, widespread flooding in central U.S. due to persistent heavy rains and thunderstorms; approximately \$21.0 (23.1) billion damage/costs; 48 deaths.
29. **Drought/Heat Wave** Summer 1993. Southeastern U.S.; about \$1.0 (1.1) billion damage/costs to agriculture; death toll undetermined.
30. **Storm/Blizzard** March 1993. "Storm of the Century" hits entire eastern seaboard with tornadoes (FL), high winds, and heavy snows (2-4 feet); \$3.0-\$6.0 (3.3-6.6) billion damage/costs; approximately 270 deaths.
31. **Nor'easter of 1992** December 1992. Slow-moving storm batters northeast U.S. coast, New England hardest hit; \$1.0-\$2.0 (1.2-2.4) billion damage/costs; 19 deaths.
32. **Hurricane Iniki** September 1992. Category 4 hurricane hits Hawaiian island of Kauai; about \$1.8 (2.2) billion damage/costs; 7 deaths.
33. **Hurricane Andrew** August 1992. Category 4 hurricane hits Florida and Louisiana, high winds damage or destroy over 125,000 homes; approximately \$27.0 (32.4) billion damage/costs; 61 deaths.
34. **Oakland Firestorm** October 1991. Oakland, California firestorm due to low humidities and high winds; approximately \$2.5 (3.3) billion damage/costs; 25 deaths.
35. **Hurricane Bob** August 1991. Category 2 hurricane—mainly coastal North Carolina, Long Island, and New England; \$1.5 (2.0) billion damage/costs; 18 deaths.
36. **Texas/Oklahoma/Louisiana/Arkansas Flooding** May 1990. Torrential rains cause flooding along the Trinity, Red, and Arkansas Rivers in TX, OK, LA, and AR; over \$1.0 (1.3) billion damage/costs; 13 deaths.
37. **Hurricane Hugo** September 1989. Category 4 hurricane devastates South and North Carolina with ~ 20 foot storm surge and severe wind damage after hitting Puerto Rico and the U.S. Virgin Islands; over \$9.0 (12.6) billion damage/costs (about \$7.1 (9.9) billion in Carolinas); 86 deaths (57--U.S. mainland, 29--U.S. Islands).
38. **Drought/Heat Wave** Summer 1988. 1998 drought in central and eastern U.S. with very severe losses to agriculture and related industries; estimated \$40.0 (56.0) billion damage/costs; estimated 5,000 to 10,000 deaths (includes heat stress-related).
39. **Hurricane Juan** October-November 1985. Category 1 hurricane--Louisiana and Southeast U.S.--severe flooding; \$1.5 (2.6) billion damage/costs; 63 deaths.
40. **Hurricane Elena** August-September 1985. Category 3 hurricane--Florida to Louisiana; \$1.3 (2.2) billion damage/costs; 4 deaths.
41. **Florida Freeze** January 1985. Severe freeze central/northern Florida; about \$1.2 (2.0) billion damage to citrus industry; no deaths.
42. **Florida Freeze** December 1983. Severe freeze central/northern Florida; about \$2.0 (3.6) billion damage to citrus industry; no deaths.

43. **Hurricane Alicia** August 1983. Category 3 hurricane--Texas; \$3.0 (5.4) billion damage/costs; 21 deaths.

44. **Drought/Heat Wave** June-September 1980. Central and eastern U.S.; estimated \$20.0 (44.0) billion damage/costs to agriculture and related industries; estimated 10,000 deaths (includes heat stress-related).

3. Global Events

The nation's climatologists in the National Oceanic and Atmospheric Administration have selected some of the most notable floods, typhoons, hurricanes, droughts, heat waves, tornadoes, winter storms, blizzards, and climate events of the 20th century, on a global basis. Factors taken into consideration included an event's magnitude, meteorological uniqueness, as well as its economic impact and death toll. Several of NOAA's top experts provided input based on their areas of expertise. The events are listed below in no particular order, and is by no means exhaustive. For more details on these and many other U.S. and global events, see NCDC's Extreme Weather and Climate Events system (Fig 1).

- Yangtze River Flood, China, 1931
- North Vietnam Flood, 1971
- Great Iran Flood, 1954
- Bangladesh Cyclone, 1970
- Bangladesh Cyclone, 1991
- China Typhoons, 1912, 1922
- Hurricane Mitch, Honduras & Nicaragua, 1998
- Typhoon Vera, Japan, 1958
- Typhoon Thelma, Philippines, 1991
- Asian Droughts (India 1900,1907,1965-67; China 1907,1928-30,1936,1941-42; and Soviet Union 1921-22)
- Sahel Drought, Africa, 1910-1914, 1940-44, 1970-85
- Iran Blizzard, 1972
- Europe Storm Surge, 1953
- Great Smog of London, 1952
- El Niño, 1982-83

One of the web pages available through NCDC's "extreme weather and climate events" system (Fig 1) is "Historical Global Extremes". Through this page you can locate many of the historical extremes, such as the lowest observed global temperature of -129 F in Vostok, Antarctica.

4. Conclusion

In fifteen of the past twenty years, there has been at least one weather-related billion dollar disaster. Since 1988, there has been at least one disaster each year--the years 1988-1990 each reporting only one disaster, and 1998 reporting seven such events, with two of the events (29%) being tropical storms or hurricanes.

For the years 1980-1999, about 24% of the billion dollar events were either hurricanes or tropical storms.

According to (Pielke and Landsea 1998) "...all else being equal, each year the United States has at least a 1 in 6 chance of experiencing losses related to hurricanes of at least 10 billion (in normalized 1996 dollars). Of course, in particular years climate patterns can significantly alter these odds (Gray et al., 1997), and in every year beyond 1995, the stakes rise due to inexorable coastal population growth and development. Consider that in 1990, Dade and Broward Counties in south Florida were home to more than the number of people who lived in 1930 in **ALL** 109 counties from Texas through Virginia along the Gulf and Atlantic coasts." (Pielke 1995).

With respect to hurricanes, the clearest evidence that explains the increases in losses points to changes in society, not in climate fluctuations. In fact, (Pielke and Landsea 1998) state, "It is only a matter of time before the nation experiences a \$50 billion or greater storm, with multibillion dollar losses becoming increasingly more frequent. Climate fluctuations that return the Atlantic basin to a period of more frequent storms will enhance the chances that this time occurs sooner, rather than later."

The general increase in population since 1900 means that more people are at risk when a major climatic event occurs. The steep increase in U.S. coastal population growth since 1900 puts a greater number of people "in harms way" when a hurricane approaches. For example, the coastal population in Florida was around 1 million in 1940, and slightly over 10 million in 1990, according to the U.S. Census Bureau. Also, the significant increase in homes and businesses located in flood plains during the past fifty years increases the risk and frequency for high-cost flooding events. If these societal trends continue, the costs associated with weather-related disasters will continue to increase, regardless of any factors associated with climate change.

5. References

Pielke, R. A. and C.W. Landsea, 1998: Normalized Hurricane Damages in the United States, 1925-1995, *Weather and Forecasting*, September 1998, 621-631.

Gray, W.M., J.D. Shaeffer, and C.W. Landsea, 1997: Climate Trends Associated with Multidecadal Variability of Atlantic Hurricane Activity. *Hurricanes, Climate and Socioeconomic Impacts*, H.F. Diaz and R.S. Pulwarty, Eds., Springer, 15-53.

Pielke, R.A., Jr., 1995: Hurricane Andrew in South Florida: Mesoscale Weather and Societal Responses. *National Center for Atmospheric Research*, 212 pp.